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Student Centered Education

Feasible Levels of Curricular Integration

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Many students struggle to interconnect biochemistry and molecular biology (BMB) contents taught in separate classes or to relate BMB to what they learn in other courses. Such students lack the necessary perspective to perceive the intradisciplinary and interdisciplinary "bonds" of BMB. In other words used before in this journal [1], they are unable to see the tertiary and quaternary structure of BMB. As teachers of BMB, we must strongly consider how to change this if we wish our students to understand what we want them to learn. Integration offers an opportunity to help students make connections, to learn better how to scaffold and organize their BMB. Research on how people learn shows us that deep learning and expertise in any discipline relies on an adequate organization of knowledge [2].

Science academies and scientific societies insistently call for interdisciplinary integration in undergraduate science education [3, 4]. However, moving from plans to action is not trouble-free. It will demand strong commitment from a large number of faculty of multiple departments. It will require coherent mapping and articulation of courses, topics, examples, and assessments. Even at the level of individual courses, programs will need to be rewritten, classes reorganized, and materials reinvented. No wonder teachers vacillate before institutional announcements of large scale curricular integration reforms. Still, more and better integration will always be good news for student-centered education and should thus be strongly encouraged. A feasible pathway toward integration would help and, in this regard, the levels of protein structure provide an inspiring metaphor.

No biochemist or teacher of BMB would describe a protein as either "having structure or not." Amidst all their complexity and diversity, the structural organization of proteins develops progressively, a few steps at a time.

Primary and secondary structures are essential for higher levels of folding and, ultimately, to the architecture and biological function of the whole macromolecule. Interdisciplinary integration relates to curricular structure. Therefore, perhaps it makes sense to look at integration also as a feature with levels of progressive complexity. Integration at the proximal scale may be as important as integration at the scale of the whole curriculum. Consequently, curricular integration should not be seen as an "on-or-off" feature, like a dipole. We should perhaps let go of the idea that curricula are "integrated or not."

Picturing different levels in curricular integration may be an interesting idea, but what should these levels be? A very interesting model [5] is a "ladder of integration" with 11 steps and four conceptual levels. The main curricular levels are (i) absolutely no interaction between courses or faculty: courses are designed by individual faculty in isolation who have no awareness about what students are being exposed to elsewhere; (ii) presence of some form of articulation: courses are still designed in isolation, but faculty are aware of what is being discussed in courses happening simultaneously; (iii) joint preparation of courses by faculty from different disciplines—the leap from the previous level is that faculty collaborate actively, have common interdisciplinary goals and introduce coherent changes in their courses to achieve those goals; (iv) interdisciplinary courses in the true sense: a multidisciplinary faculty team prepares, teaches, and assesses the course. In the most sophisticated level of integration, the names of disciplines may no longer be visible in course designations for example, biochemistry can be pivotal in a course designated "cells and molecules."

Picturing integration by levels is empowering since and makes integration feasible. If we consider the "primary integration" of a curriculum, the way courses are linearly displayed in a program, then the "secondary integration" would be that neighboring course establish interactions and thus benefit mutually from what students are learning next-door. Clearly, the secondary level of integration

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is within the reach of individual faculty. It further suggests that one or two faculty members can provide integration for example by being aware of (i) what is being covered in other courses, in general terms—this would for example eliminate useless duplications of content; (ii) the examples seen by students in other courses—a common set of examples to anchor content from different disciplines helps students to figure out the contribution of different disciplines to address scientific issues; (iii) the laboratory classes that are running in other courses—being explicit with students about the connection of different courses through experiments, we will be emphasizing the value of interdisciplinary research.

Integration at the lower levels centers education on students and may be extremely rewarding. Should we wish our students to develop their expertise in using BMB to tackle real world multidisciplinary issues, we should think about focusing on the level of integration which is feasible for us within our teaching contexts. We need not necessarily wait for massive institutional reforms to begin implementing discipline integration. In fact, we could start immediately in a student centered way, by asking our students and/or our colleagues what is happening in the next and in the previous classes. It is important to bear in mind that multidisciplinary integration is not an all or none feature.

REFERENCES

[1] H. White (1998). The tertiary and quaternary structure of biochemistry a pedagogical analogy. *Biochem. Educ.* **26**, 1
[2] J. D. Bransford, A. L. Brown, R. R. Cocking, Eds. (2000) How People Learn: Brain, Mind, Experience and School, National Academy Press, Washington, DC.
[3] Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century, National Research Council. BIO2010: Transforming Undergraduate Education for Future Research Biologists (2003) National Academies of Science, Washington, DC. Available at: www.nap.edu/books/0309085357/html. Accessed December 2010.
[4] Teagle Working Group for ASBMB (2008) Biochemistry/Molecular Biology and Liberal Education: A Report to the Teagle Foundation. Available at: http://www.asbmb.org/uploadedFiles/ProfessionalDevelopment/Resources/Teagle%20Report(1).pdf. Accessed December 2010.
[5] R. Harden (2000). The integration ladder: a tool for curriculum planning and evaluation. *Med. Educ.* **34**, 551–557.